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SHORT TERM WEATHER FORECASTING IN REAL TIME IN A BASE WEATHER STATION SETTING

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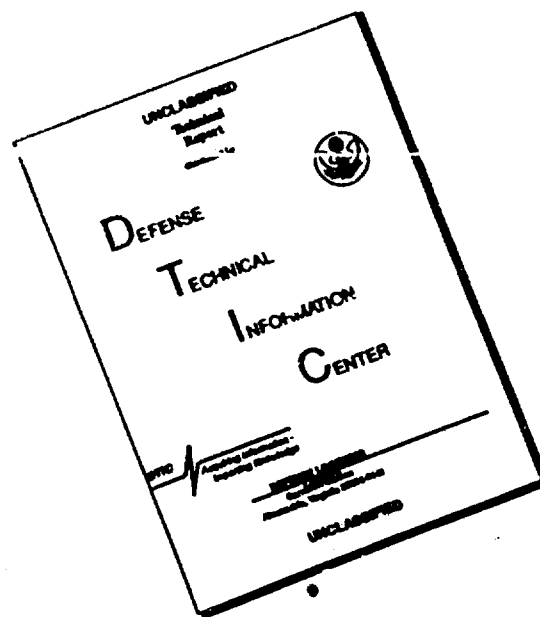
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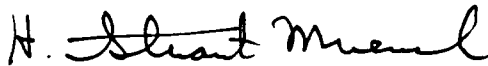
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13. ABSTRACT (Maximum 200 words) Starting with computer code for a research model developed by Seitter and Colby (1992), initial steps were taken to make the model a real-time forecasting tool. Several procedures are required to initialize and run the model from real data. The code to automate this process has been written and tested. In addition, an error condition in the interactive nesting region related to terrain has been corrected.				
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1. Introduction

Mesoscale modeling is still the province of research institutions rather than the tool of operational forecasters. The primary problem with mesoscale models is that either they require supercomputer power such as is available from a Cray computer, or they are too slow to produce useful results in time to be useful as predictions. Thus, despite the clear needs of forecasters for mesoscale guidance, most operational forecasters must use output from synoptic-scale models such as the Nested Grid Model (NGM) from the National Meteorological Center. The grid size of this model is about 90 km, which results in unacceptable resolution for mesoscale events. For example, the entire region of Massachusetts, Connecticut and Rhode Island is contained within four NGM grid boxes. Not even the seabreeze circulation can be resolved in a model such as the NGM.

As described in Seitter and Colby (1992), a simplified, but physically complete model can be developed which can run on a relatively small computer in real-time. The following report describes the steps taken during the past year to provide automatic initialization of the model from real data, a necessary and important requirement for running the model in an operational mode. In addition, an error involving the New England terrain has been corrected, thus reducing noise in the simulations.

2. Noise

As tests were conducted with the model using an idealized New England initial data set, computational noise appeared along the northern edge of the fine mesh domain. This noise amplified over time, and eventually became unstable, causing the model to crash. Figure 1 shows the initial data for this hypothetical case, data which are very smooth initially. The pressure field was initialized to be in approximate geostrophic balance with zonal winds of 10 knots at all levels. One thermodynamic sounding was

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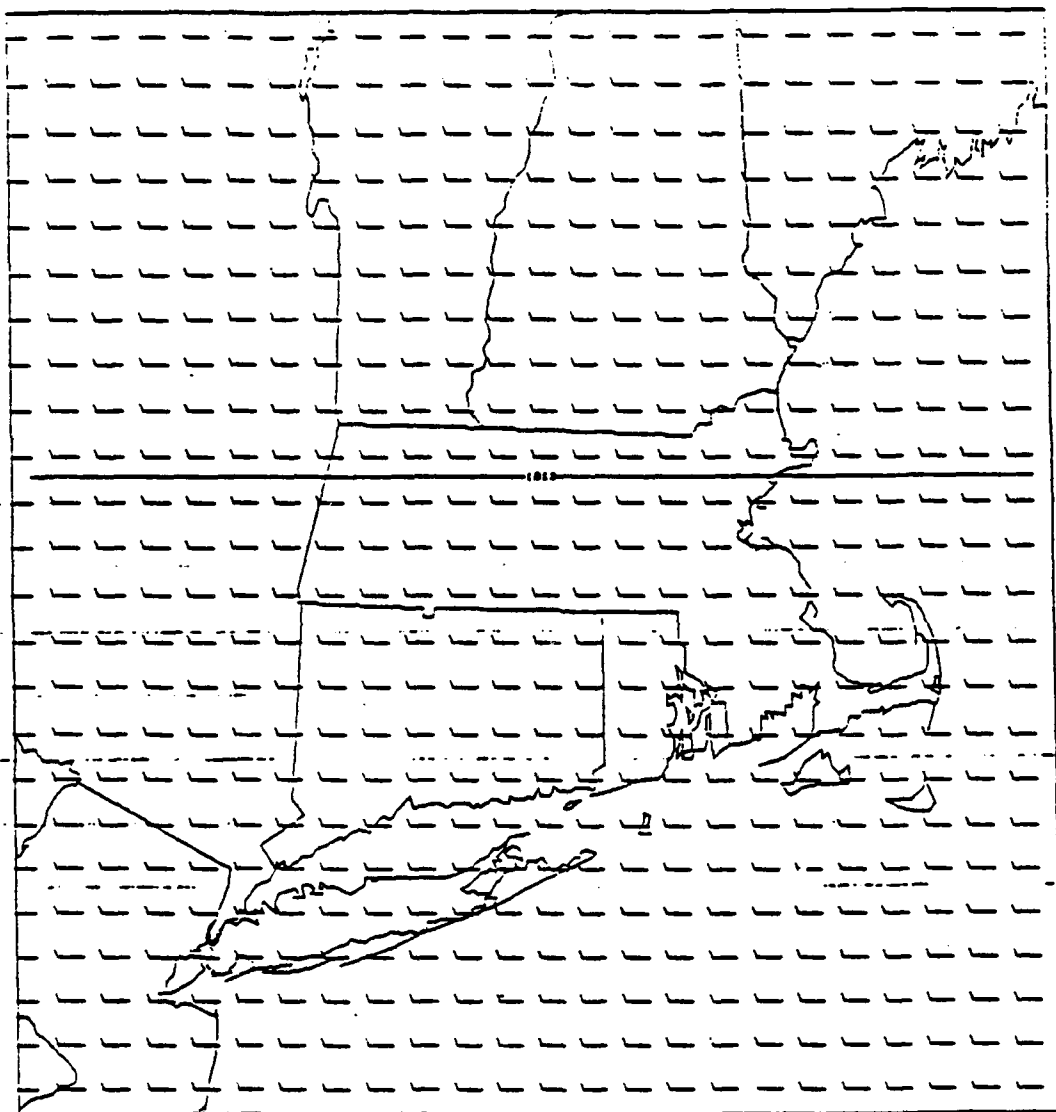
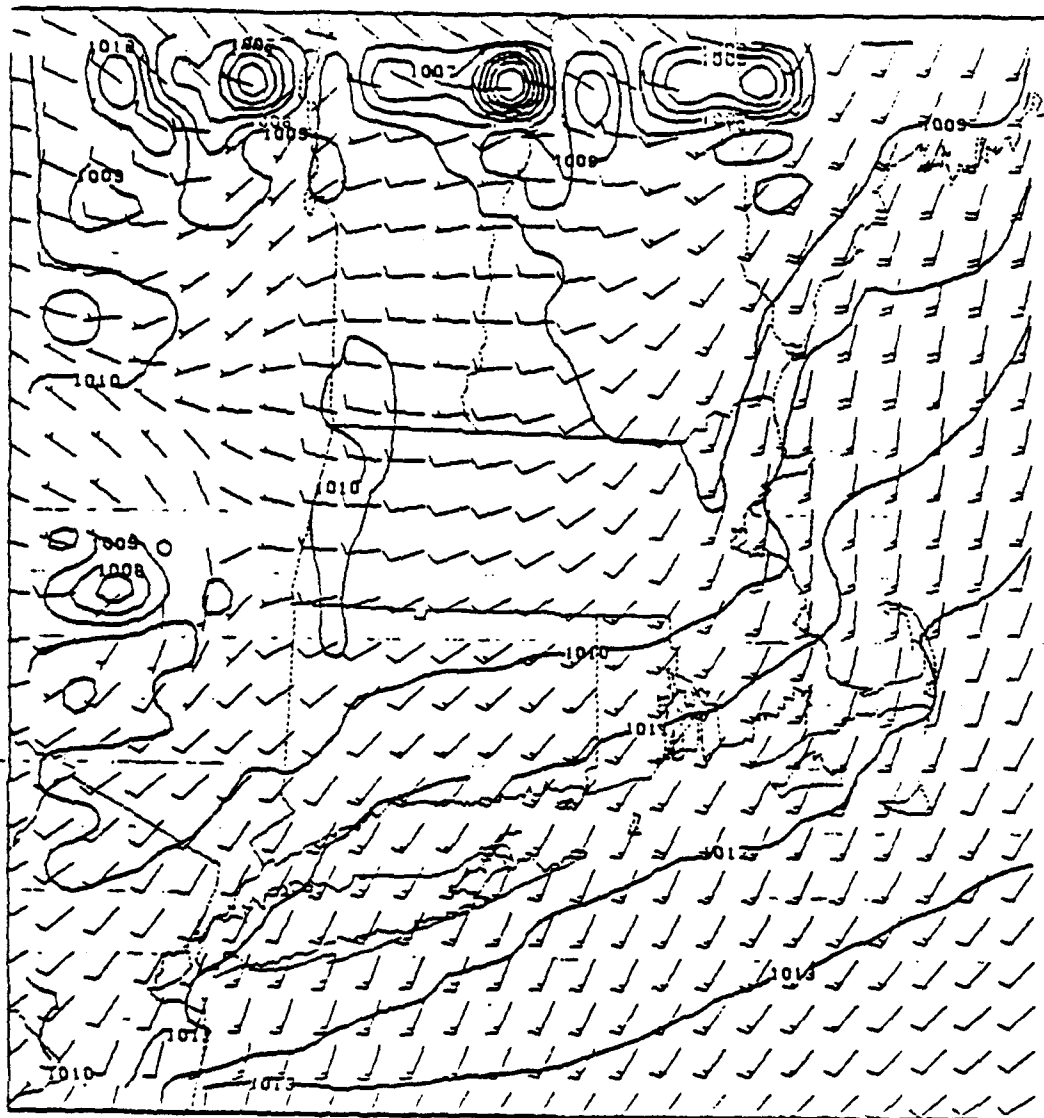


Figure 1. Initial winds and sea level pressure (mb) over fine grid mesh for simple, one-sounding initialization. Winds plotted according to normal conventions.

input and spread to all grid points, thus there were no temperature gradients above the surface.

After 12 hours, the model solution in the fine grid domain is as shown in Fig. 2, in which the noise in the sea level pressure field is quite prominent. A series of high and low pressure regions appears along the northern boundary, features which not only did not appear in the real data, but which are unrealistic meteorological features. With general west-northwest flow, and the absence of any forcing aloft, there is no reason for a pressure field such as this.

For a number of reasons, we suspected that the problem lay in the terrain field in the interface region. The scale of the waves, while not on the order of twice the grid size, is nonetheless regular, suggesting a numerical instability. This noise looks very much like a set of waves running along the interface region. The terrain in this area is a series of ridges and valleys, and the zonal wind would blow essentially perpendicular to these terrain features. Additionally, after presenting this figure in a talk at the Naval Postgraduate School in Monterey, a scientist in the audience remarked that these waves were similar to features she had encountered in a mesoscale modeling situation which were related to terrain problems. After some experimentation, we finally smoothed out this terrain, and were able to integrate the model over a complete 24 hour cycle without generating these waves. Further experimentation led to a partially smoothed terrain field in the interface region, as shown in Fig. 3. The model solution is shown in Fig. 4 for 12 hours, a time near when the model had been crashing. Obviously, the field is much more coherent. The field at 24 hours is as shown in Fig. 5. The initial field is not reproduced, as the day's heating and the zonal wind flow have made some permanent changes. Nevertheless, the final field looks quite reasonable and is qualitatively quite similar to the initial data field 24 hours previous.



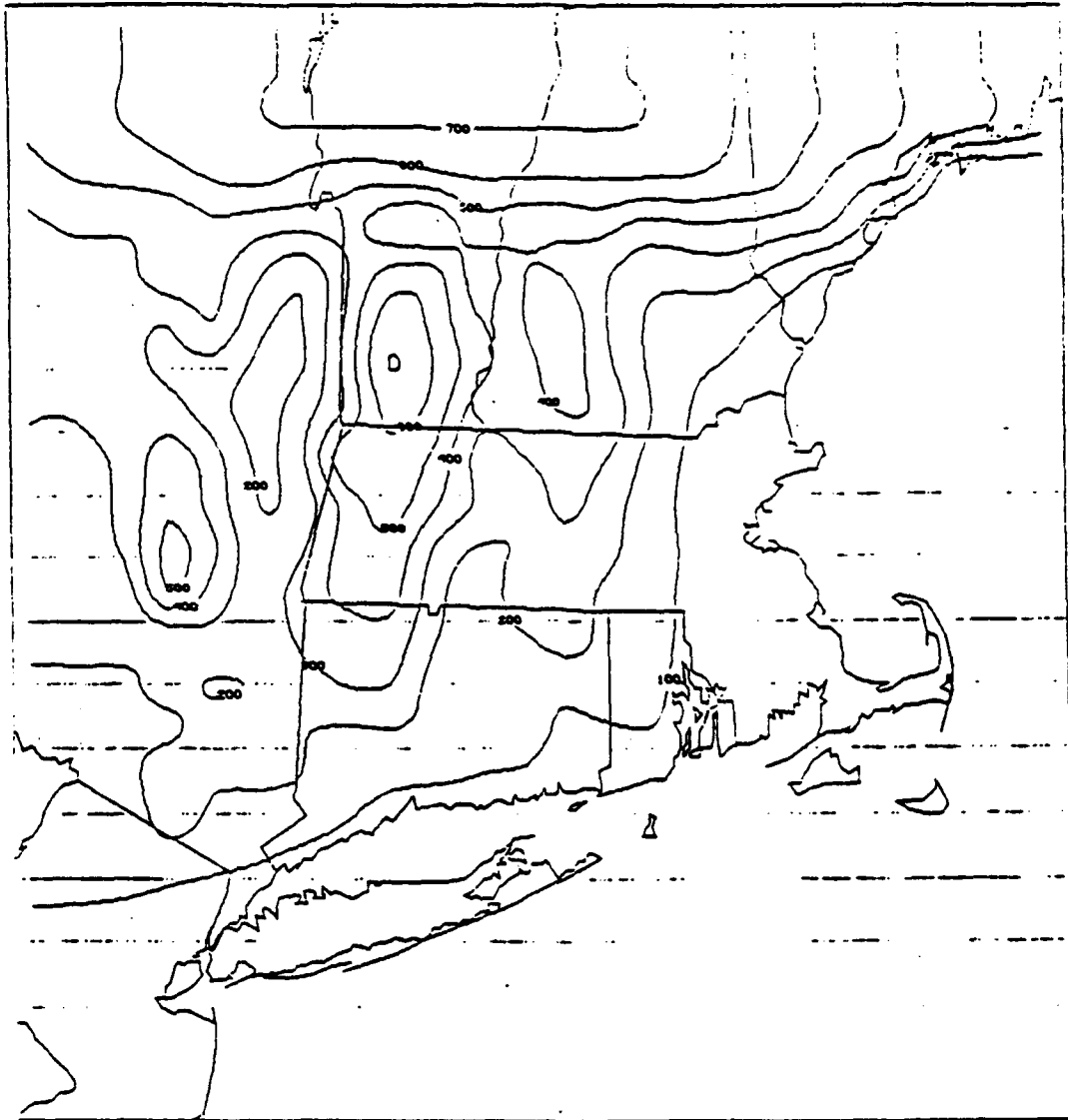


Figure 3. Terrain for the fine mesh in meters.

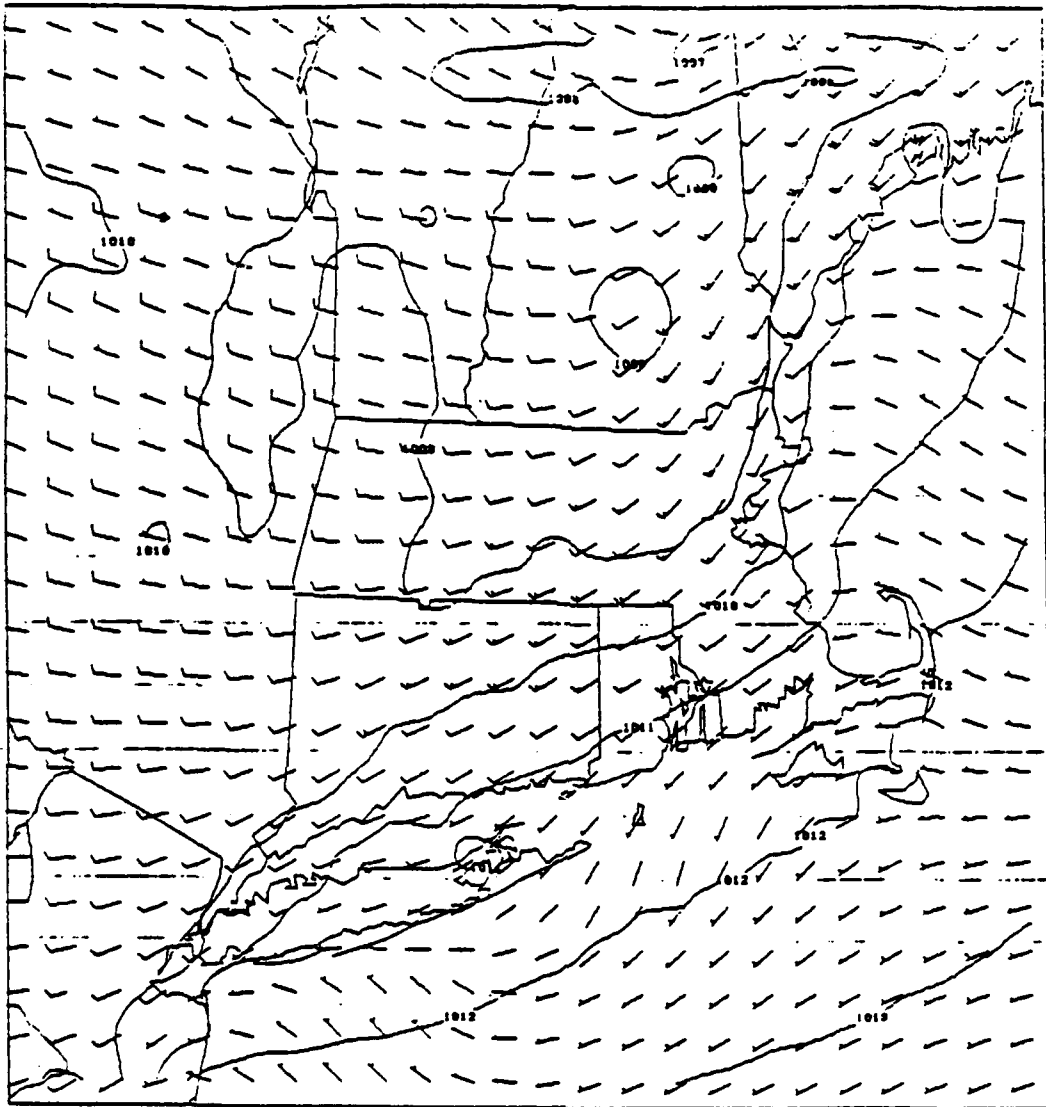


Figure 4. As in Fig. 2 for model run with terrain as shown in Fig. 3.

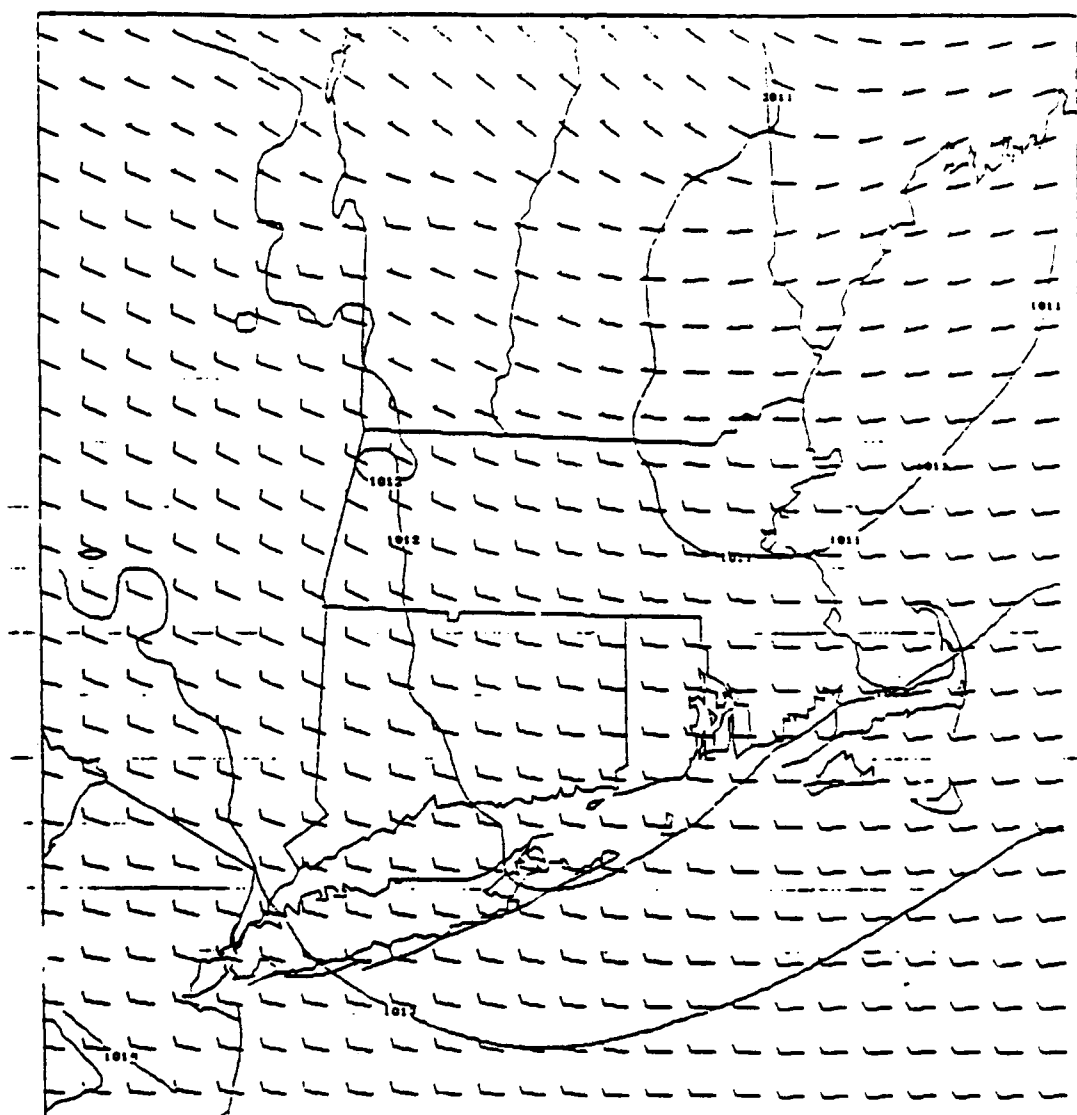


Figure 5. As in Fig. 4 after 24 hours of model integration.

3. Automatic Initialization

One of the major objectives of the current contract is to develop the ability to run the model in an operational setting. As a step in this direction and to test the model's ability to use real fields, we decided to use real data to initialize the model. This would also allow us to find out if the model could reproduce reality in New England terrain. We need a three-dimensional data set which includes pressure, temperature, humidity, and wind data over both fine and coarse grid domains. The data available operationally include the North American radiosonde data at 00 and 12 UTC, and the surface airways hourly reports. Ship and buoy data are also available, but have not been explored nor merged with the other data at this time.

We had initially planned to produce a set of initial fields by hand calculation, but it became quite obvious that this process would be long and tedious. With the GEMPAK graphics code, which has the capability to grid real data using the Barnes-type analysis scheme, it seemed obvious that we would be better off writing the code to prepare the fields for the model automatically, since this was a capability we would eventually need.

This process was not as simple as it had first appeared. We already had experience gridding surface data, but the extrapolation to upper air data was not straightforward. The fields produced were very lumpy, unrealistic, and, as it turned out, unbalanced. Additional problems cropped up with the order of grid points produced by the GEMPAK software. Eventually, the necessary code was developed and debugged.

Several steps are required to facilitate model initialization: decoding of raw data, gridding the decoded data, checking the grids for bad observations, extrapolating the gridded data into data-void regions, and finally interpolating the gridded data onto the model's surfaces. Most of these steps use routines included with our Gempak

graphics software package.

Raw upper air data are received at 00 and 12 UTC daily on our computer from the network of stations in North America. To use these data in the model, we run a Gempak decoder which unpacks and rearranges the data for each sounding location. A second Gempak routine runs through this decoded data to find those locations which fall within a region which surrounds our model coarse grid. Many experiments were required to find the optimal region for this process; too small a region resulted in a poor interpolation, while too large a region gave results which were excessively smooth. The current analysis uses data within 5 degrees of latitude of our model coarse grid domain.

A second series of Gempak routines is then run to produce gridded data over both the coarse and fine grid model domains. Gridded fields are produced at 100 mb intervals from the surface to 100 mb for each of the important model variables: temperature, mixing ratio, and surface pressure. Wind fields are also produced (u and v components) but are not presently used in the model initialization.

The next step incorporates the last three processes referred to above. Our own routine reads the output fields into a series of arrays. Each data value is checked for out of bounds values; Gempak inserts a flag value for missing data. Missing or unusual values are flagged, and at the present time, the computer operator is queried to provide a correct value. This is most important for our current model domain, since a large part of it extends over the Atlantic Ocean. The Gempak interpolation scheme is unable to provide data for part of this region, since there are no upper air soundings there. We presently use either National Weather Service operational analyses to provide data for these grid points, or extrapolate the current analysis out to the domain edges. This is primarily a problem only for the coarse grid; the fine grid domain is close enough to the coast for the Gempak analysis to completely cover it.

The routine then proceeds to interpolate the 100 mb spaced fields to the model eta levels. Each point in the domain must be handled individually, since the vertical levels all depend upon the surface pressure, which varies with grid point elevation. Everything is done in a manner to ensure consistency between the model terrain and the resulting fields. After this process is complete, the fields are written out to disk files in a format ready for the actual model.

Within the model, immediately after the data are read in, the u and v components are computed using geostrophic balance. This is admittedly an overly simple initialization, but it ensures a smooth and noise-free model domain. Eventually, after condensation is added to the model, we intend to introduce initial divergence consistent with initial precipitation. Until then, we will continue to use the geostrophic balance initialization.

4 Case Study

We have run several case studies to test this process; some have been successful and some have not. The problem with the unsuccessful runs seems to be with bad data which manage to pass through our quality control checks. We are continuing to work on this problem. We have also had some trouble with Gempak routines being unable to always properly decode sounding data. The case study shown here is one which has worked quite well. The data are from 10 July 1992, and are characterized by relatively strong northwesterly flow at most levels in the atmosphere. The initial fields (not shown) are smooth, and show northwest flow at both the surface and aloft. In the figures that follow, notice that the display of output has been modified to produce maps at standard levels in the atmosphere instead of at model eta levels. This makes it much easier to interpret the output, as well as compare it to actual NMC analyses.

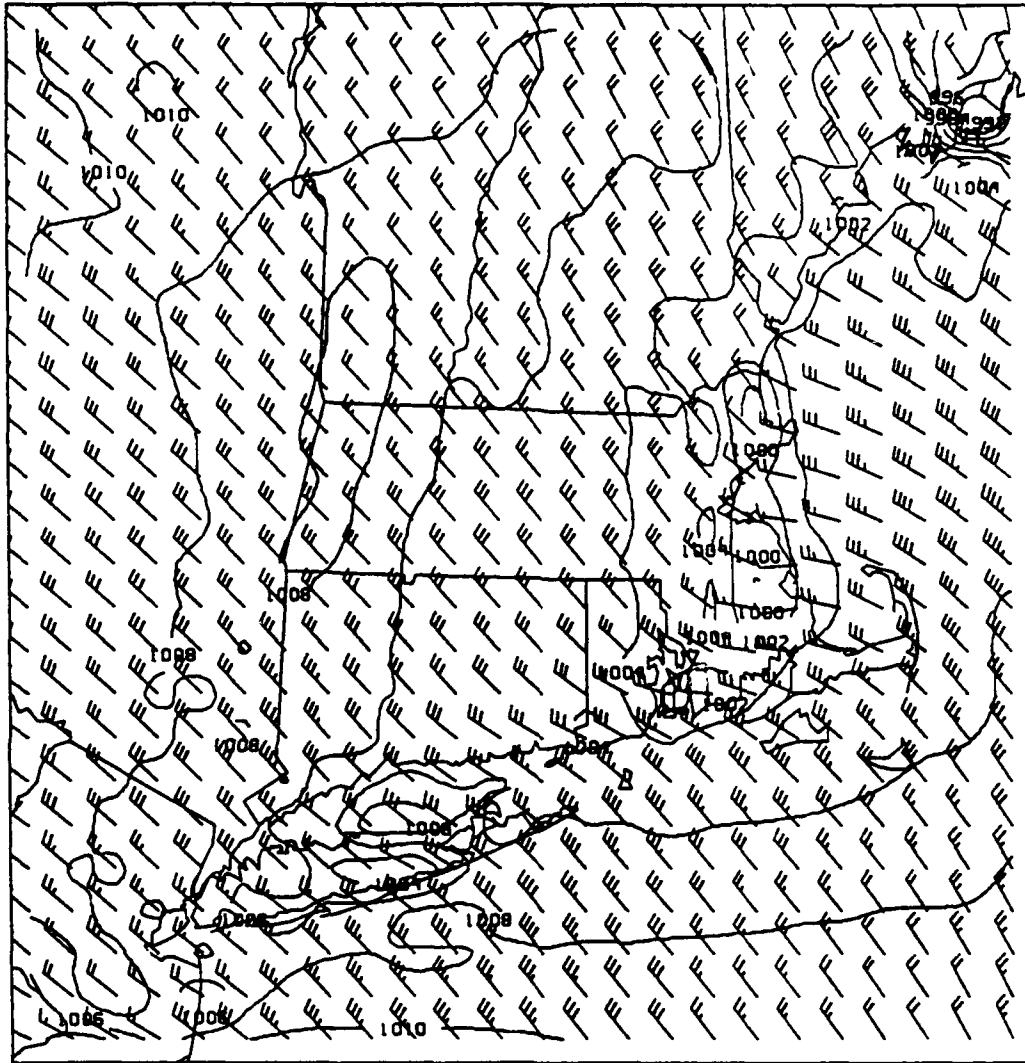


Figure 6. Fine mesh solution after 12 hours of model integration using initial data from 10 July 1992. Contours show sea level pressure in mb, and winds are plotted conventionally in knots.

After 12 hours (almost 6 PM local time), the fields have changed as shown in Figs. 6 and 7. Notice that a trough has developed along the coast in response to differential heating over the land and the sea. The northwesterly flow is too strong to permit an actual sea breeze to develop, despite the new pressure gradient. By 18 hours (about midnight local time), this trough has largely disappeared, and the flow is back to its northwesterly orientation (see Figs. 8 and 9). At 24 hours (just after sunrise the next day), the fields look very much as they did at the initial time (Figs. 10 and 11).

When we compare these last two figures with the actual NMC analyses we can see that the model results do not duplicate reality. Further comparison, however, reveals that the ridge feature which produced the initial northwest winds had largely relaxed during the following 24 hours. Since this model run uses fixed boundary conditions, there is no way for this to be reproduced in the model run. Thus, we are encouraged by the model performance, but are now ready to introduce time dependency in the boundary conditions.

5. Future Work

The effort to incorporate variable boundary conditions is ongoing. The code has been written to allow either the use of 12 hour data (as are available now for past case studies) or the use of 3 hourly data which will be available in a forecast mode in real time from the NGM grid point data stream. Two other small efforts are continuing. We have found that our new MicroVAX 4000 VLC workstations are more than twice as fast as the MicroVAX 3500. Thus, we have set up the model to run on one of these workstations to speed up development work. Current computer technology clearly has advanced significantly, and will allow greater complexity to be added to the model without compromising the real-time availability of the model results. The second small effort which is in progress is the incorporation of a dry convective adjustment scheme. We found that under certain circumstances, the model was developing absolute instability at some grid points. A scheme to correct

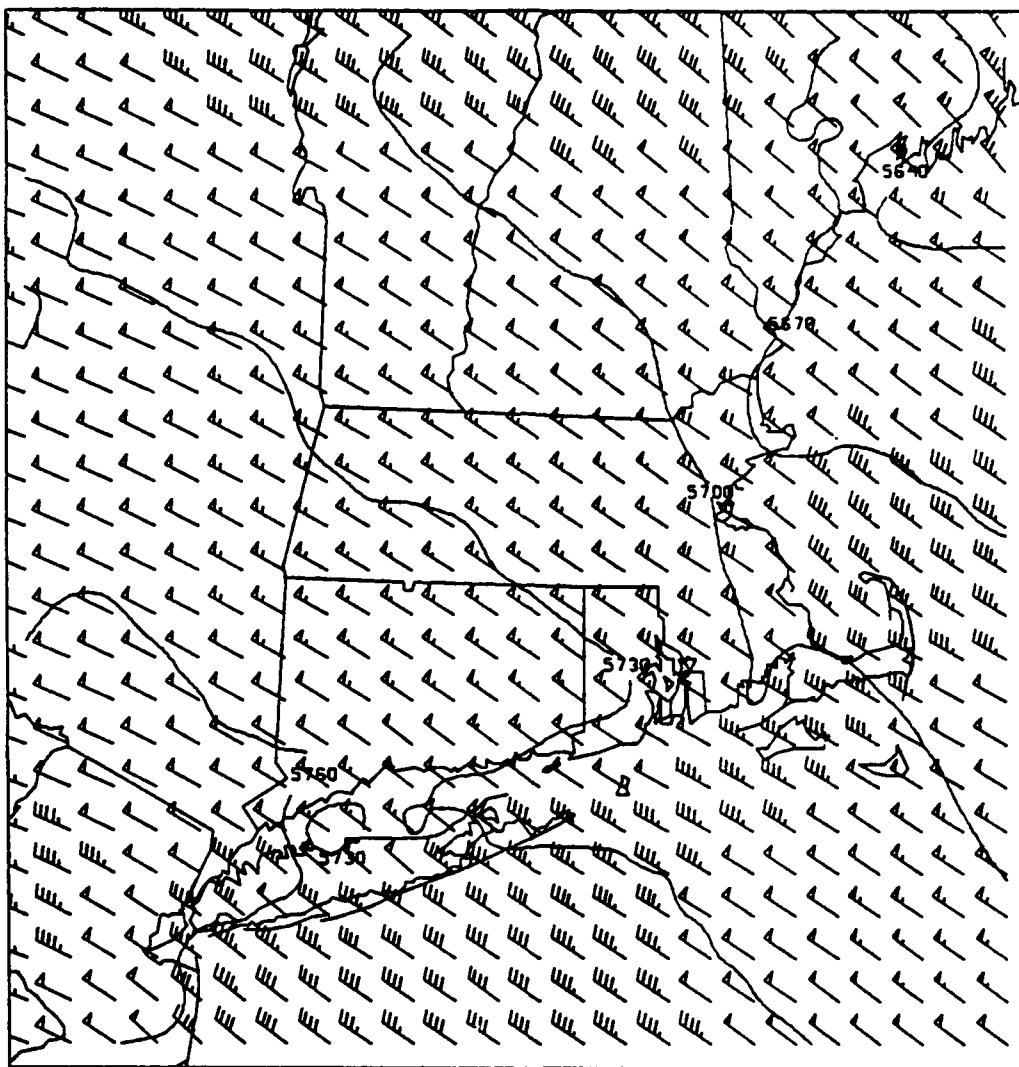


Figure 7. As in Fig. 6, but showing 500 mb height contours in meters.

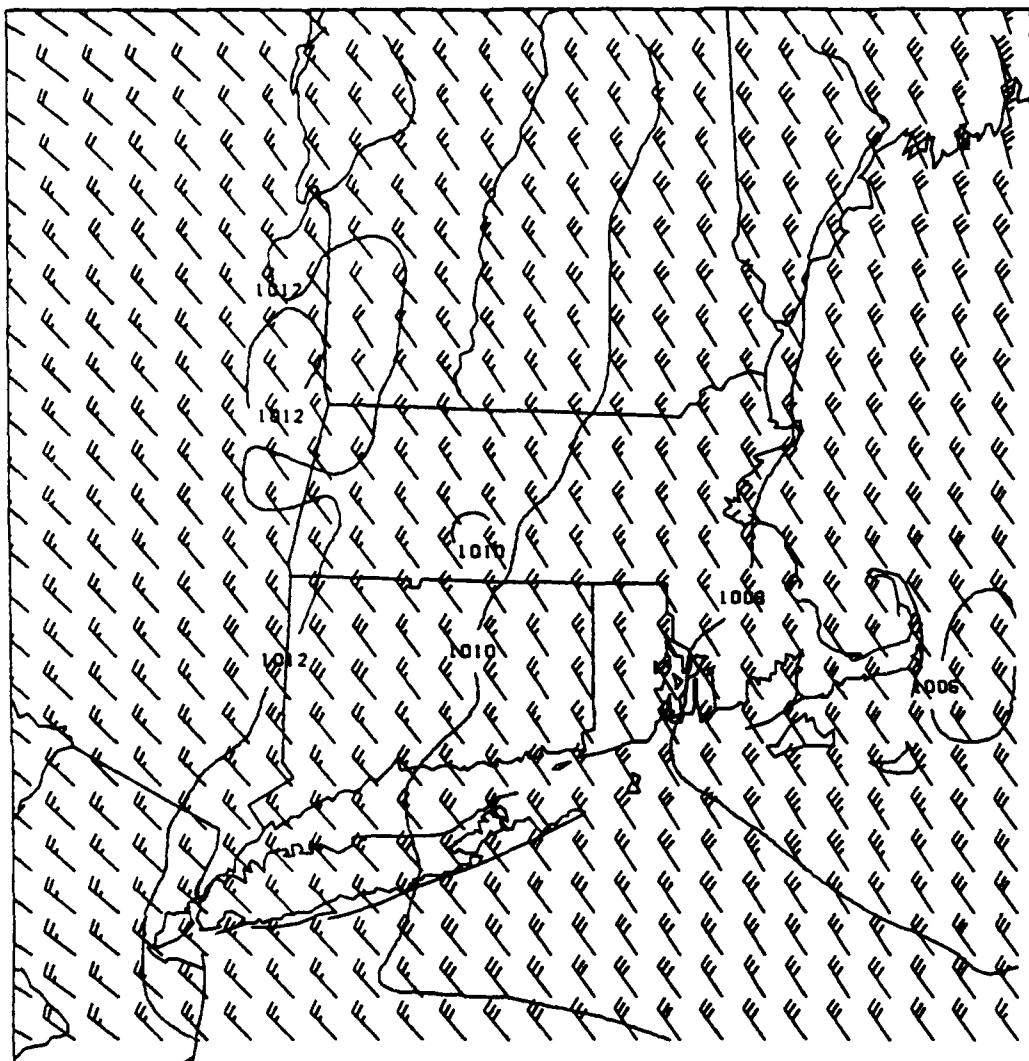


Figure 8. As in Fig. 6 after 18 hours of integration.

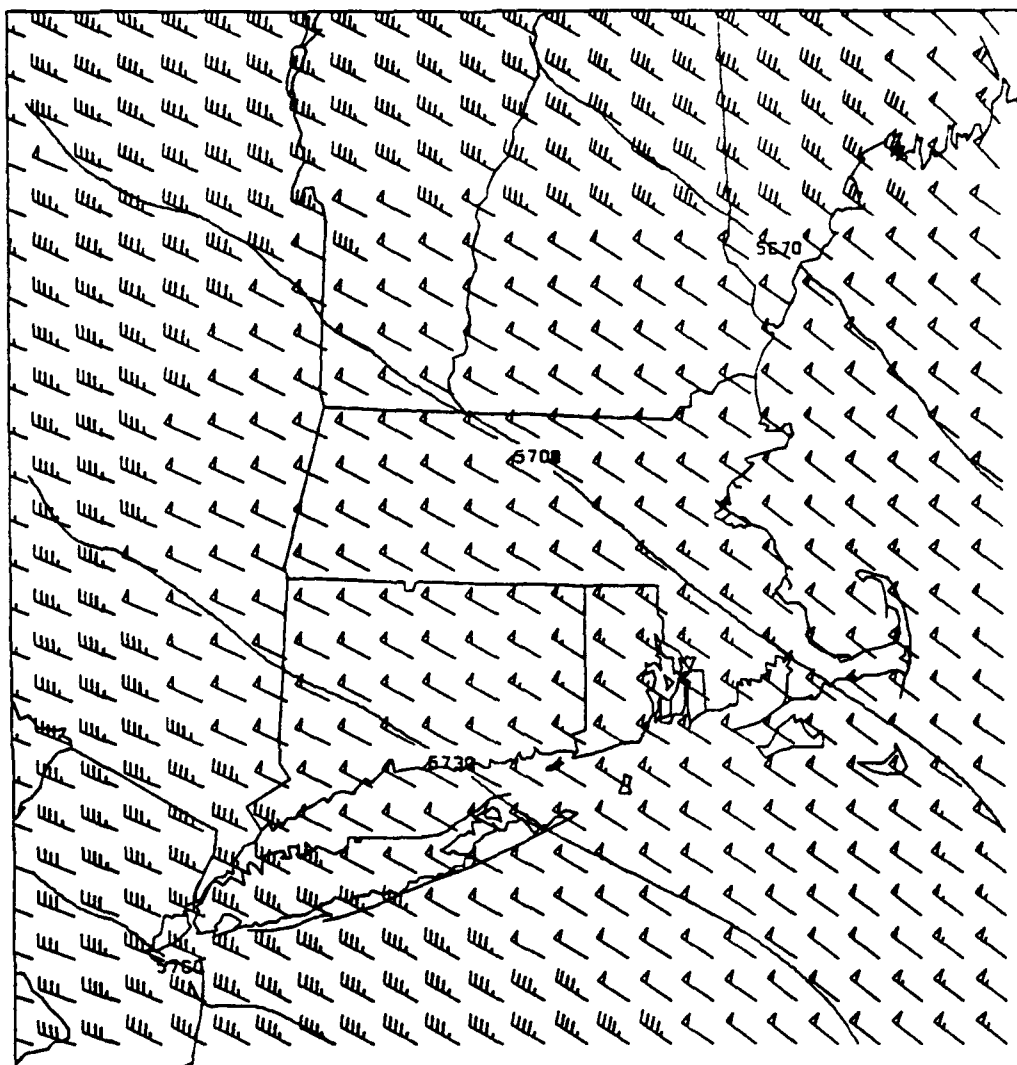


Figure 9. As in Fig. 7 after 18 hours of integration.

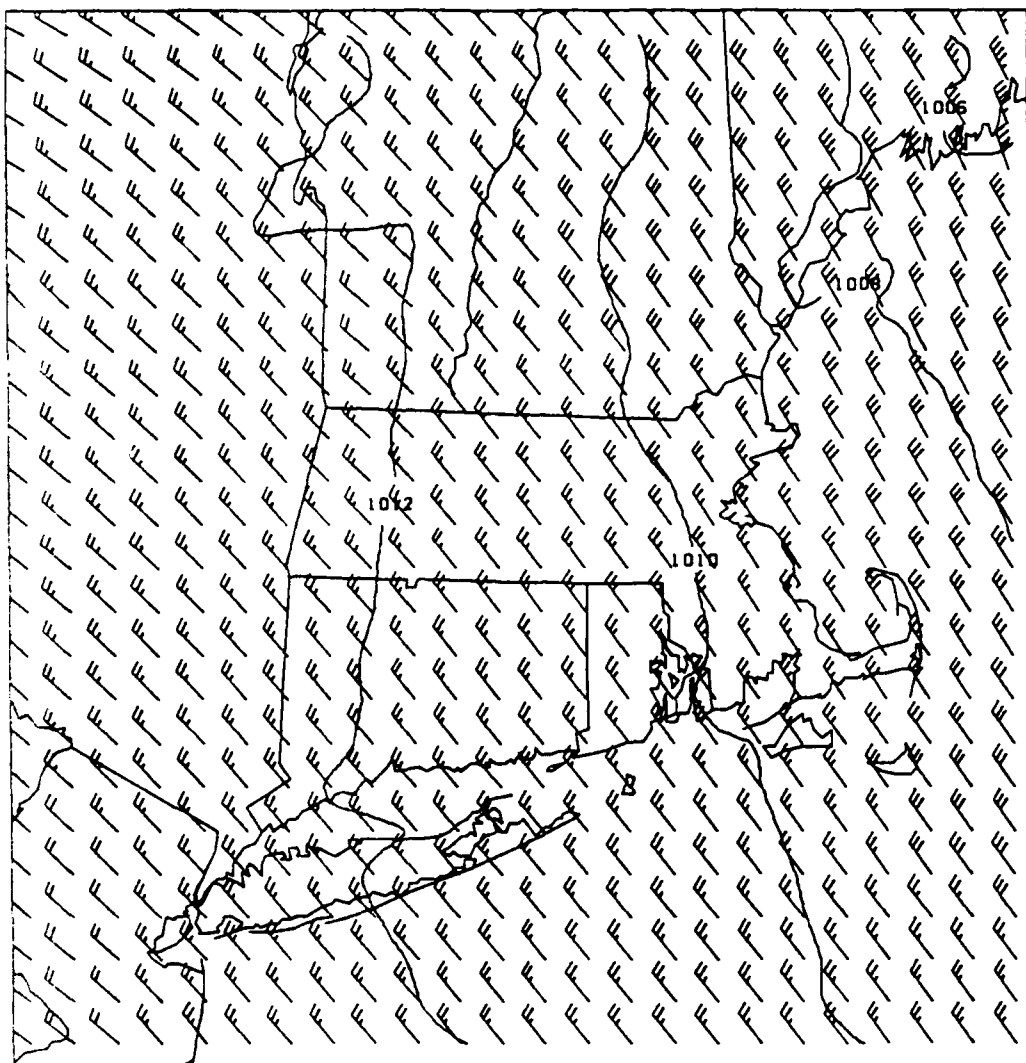


Figure 10. As in Fig. 6 after 24 hours of integration.

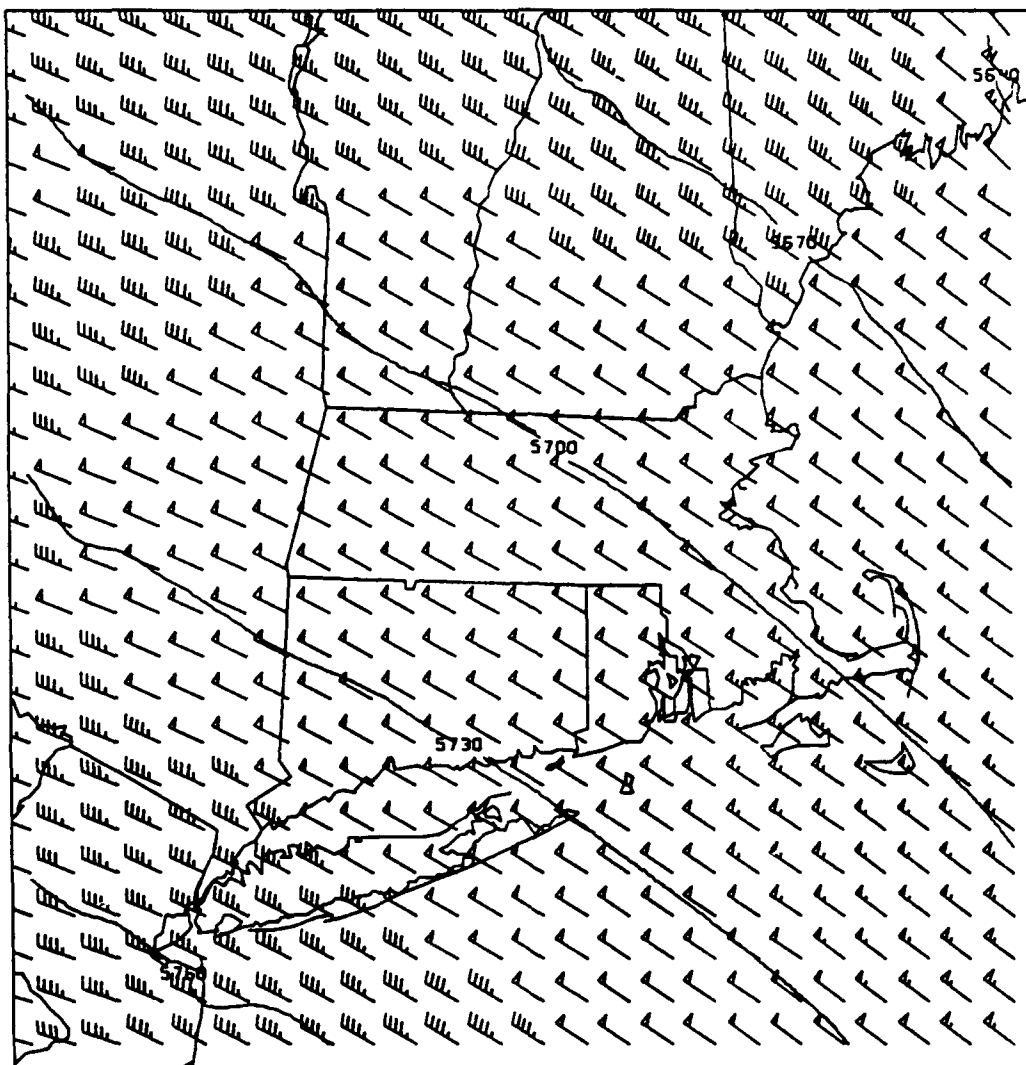


Figure 11. As in Fig. 7 after 24 hours of integration.

this has been written, but not fully debugged. Work on this will continue. The next major effort will be to include first clouds and then precipitation processes in the model. This is obviously crucial to model utility and will represent a major effort over the next year.

6. References

Seitter, Keith L., and Frank P. Colby, Jr., 1992: "A meso-beta scale model in boundary-layer coordinates", to appear in *Monthly Weather Review*.